mirable patience and perseverance whenever any doubt of previous conclusions was felt by himself or reasonably expressed by others. He has practised what he urged on his younger colleagues at the opening of the Pasteur Institute: "N'avancez rien qui ne puisse être prouvé d'une façon simple et décisive." Besides, with all his mental power and caution, we can see, in the course and results of Pasteur's work, the evidence of rare courage and strong will, and of singular skill in the use of the best means of scientific investigation. He has been chemist, microscopist, and naturalist, and has applied all the knowledge thus gained to the practical study of pathology. It is not strange that he has attained the results of which the best, and only the best, have here been told.

The honours that have been bestowed on Pasteur need not be mentioned. His chief reward may be in the happiness of seeing some of the results of his life-long work; and, indeed, very few scientific men have lived to see their work bear such good and abundant fruit. No field of biological study has in the last twenty years been so effectually studied as that which he opened, and in which he showed the right methods of research. Now, wherever biology is largely taught, the bacteriological laboratory has its place with the chemical and the physiological; and, for a memorial of the gratitude not only of France, but of many other nations, there is in Paris the Pasteur Institute, which was constructed at a cost of more than £100,000, and was opened in 1889. Here, he may not only see the daily use of his treatment for the prevention of rabies, but may observe and still take his part in the extension of the vast range of knowledge in which there has been constant increase ever since the first sure steps were made by his discoveries.

JAMES PAGET.

THE PAST HISTORY OF THE GREAT SALT LAKE (UTAH).

Lake Bonneville. By Grove Karl Gilbert. "Monographs of the United States Geological Survey," Vol. I. (Washington, 1890.)

WEST of the Rocky Mountains, inclosed by regions which drain to the Pacific, is the extensive area which bears the name of the Great Basin, for from it there is no outflow. This basin in form is rudely triangular, the most acute angle pointing southward, and its greatest length is about 880 miles. At the broader end the general elevation of the wide valleys or plains, which intervene between a series of parallel ridges, is about 5000 feet above the sea; at the narrower end the ground descends gradually till it is about on, or even below, the sea-level. Streams empty themselves into inland lakes in different parts of the Basin, the most important of these being familiar to everyone as the Great Salt Lake of Utah. This, however, is only the shrunken representative of a grander predecessor, a mere brine-pan compared with its fresh and far-spread waters. To a height of about 1000 feet above the present surface, the evidence of lacustrine wave-work and lacustrine sedimentation can still be traced, and to the lake thus indicated the American geologists have given the name of Lake Bonneville. This, in general outline, was rudely pear-shaped, but its shore-line was very irregular, a succession of jutting headlands and deep bays; its surface also was broken with islands. Its area measured about 19,750 miles, not much less than that of Lake Huron. This is now a region of arid deserts, spotted here and there with a salt marsh or a lagoon, and diversified by the Great Salt Lake and two others of smaller size. The greatest depth was originally 1050 feet, for the Great Salt Lake does not exceed 50 feet in any part. Then the waters of Lake Bonneville found an outlet at the northern end, not far away from the mouth of the Bear River, which is now the principal affluent of the Salt Lake. The rainfall then in the northern part of the Great Basin must have been much heavier than it is now; as it diminished, Lake Bonneville contracted in size and increased in saltness. The annual rainfall in this district is now only about 7 inches, while over the region between the Appalachians and the Mississippi it is 43 inches. In the latter the average moisture in the air is about 69 per cent. of saturation, in the former it is only 45; while the evaporation from the surface of Lake Michigan is only 22 inches per annum, for the Great Salt Lake it amounts to 80 inches. The level of the water in the latter is subject to oscillations, dependent partly on variations in the rainfall, partly on the results of extended cultivation, and appears likely in the future to fall somewhat below its present height.

In the disappearance of the ancient lake, epochs—sometimes perhaps rather long—of stability appear to have alternated with eras of change; at any rate, shore-cliffs, terraces, spits, and bars of detritus are very distinctly grouped at intervals above the present water-level. Owing to the scanty rainfall, and the absence, until late years, of any attempt at cultivation, these natural features are preserved with unusual distinctness. In the admirable plates by which the memoir is illustrated, we can see the enclosing hills, bare and arid, but furrowed into a thousand gulleys by the transient storms of myriad years; the wave-worn cliffs which overlooked the margin of the vanished lake; the long shelving slopes which formed its bed; the water-worn *débris*, here accumulated in a long spit, and indicating the general set of the waves; there piled up in a bar, which now runs, like a railway embankment, from headland to headland across the opening of a bay. The plates in themselves are an object-lesson in physical geography.

The origin of the basin of Lake Bonneville, as of all other large lake basins, is undoubtedly, as Mr. Gilbert points out, deformation of the earth's crust, or *diastrophism*, as he proposes to call it. But there is evidence to show—and this is a point of much interest—that during the process of desiccation, this crust has not remained absolutely at rest; these "bench marks" afforded by the lake margins have undergone movements which are not uniform in amount. They are found, on examination, to exhibit variations amounting in some cases to about 350 feet in altitude. Faults, also, may be traced for considerable distances which are later in date than the desiccation of Lake Bonneville. These in places are made very distinct by scarps, crossing lines of terraces or alluvial fans, and facing outwards towards the lower ground. These faults, however, do not indicate any great displacement. The maximum throw does not exceed about 60 feet, and it is often less. Certain localities

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also have been disturbed by volcanic eruptions. These have occurred before, during, and since, the epoch of the greatest extension of Lake Bonneville. Craters of scoria, as well as flows of lava, remain as monuments—the former occasionally three or four hundred yards in diameter, the latter sometimes a little more than three miles long; the materials are all basaltic. Rhyolitic lavas also occur in the region, but these are long anterior in date to the epoch of the lake. Organic remains are not common in the marls and other deposits of the old lake-bed. This is not surprising in the later period of its history, but they might have been expected in greater abundance in that when the waters were still fresh. The earliest deposits do not carry us back beyond the Pleistocene age, so that, geologically speaking, both the formation and desiccation of the lake are modern events.

This is a bare outline of the last pages of the story of a remarkable district in America, the like of which can be found in more than one other locality on the earth, though, perhaps, in none of them is the record so clearly preserved. Mr. Gilbert's memoir is not only a most careful description and full discussion of the various phenomena presented by this singular dried-up region, but also he turns, not seldom, to questions of wider import, on which, however, want of space forbids us to touch. Moreover, the second chapter of the volume is occupied by a very full discussion of the various topographical features of lake shores. Perhaps in this the author errs occasionally on the side of prolixity, but he brings together so much valuable information that the book will be indispensable to all who wish to study the history and phenomena of lakes and inland seas. We lay it down with a deep sense of gratitude to him for the loving labour which he has evidently bestowed upon this memoir, and will only add that, high as the standard already attained by the publications of the American Geological Survey may be, this monograph, especially in the work of the printer, and in the number, interest, and excellence of its illustrations, more than attains to it. T. G. Bonney.

ON DUCKS AND AUKS.

On the Morphology of the Duck and Auk Tribes. By W. Kitchen Parker, F.R.S. With Nine Plates. (London: Williams and Norgate, 1890.)

When the grave, a few months ago, closed over the remains of W. Kitchen Parker, there still remained with those who knew him the memory of an excellent man and brilliant anatomist. None save one devoted to the science could have worked on as he did, often amid many cares and troubles, feeling a high delight in his work, and considering the attainment of knowledge to be its own reward. From a very early period of his life all his spare moments were devoted to anatomical research, and the hour of death overtook him while as yet, though full of years, he was labouring still.

One of his latest, if not his last work, lies before us. It treats of the morphology of the Anatidæ and the Alcidæ, and has been published by the Royal Irish Academy, as one of its "Cunningham Memoirs." It may be necessary to add that these memoirs are published from the resources of a fund left to the Irish Academy by a Mr. Cunningham, and that great care is taken that the memoirs published therein shall be of a high order of merit.

Most of the materials for this memoir had been in the late Dr. W. K. Parker's hands for many years, but those which he needed to complete his investigations had been only obtained during the last few years from several friends. In a brief introduction he states that for many years after the publication of his first two papers on the osteology of birds (1850-60), his attention was directed solely to the skull. The burden of the anatomy of the skull was placed upon his willing shoulders by Prof. Huxley, who then by degrees tempted him into the investigation of the organs of support, which have proved to be of as great interest and profit as the anatomy of the skull itself.

The two families of birds whose morphology is treated of in this memoir are very distantly related, and the true position and genealogy of the duck tribe present as tough a problem as those of the auk tribe; indeed, herein is enough, Mr. Parker writes, to task the ingenuity and strength of two or three generations of biologists. The cranium in Cygnus and its vertebral column are described from an early stage; the wings of Cygnus and Anas and the hip-girdle of Anas in various stages of development are noticed. Among the auks, *Uria troile* has been selected for description.

In a summary of nearly seven pages, it is pointed out that the Anatidæ manifestly converge towards the Gallinaceous group; that they have the Struthious division of the Ratitæ obliquely below them; whilst the Alcidæ are related to a large and varied group of existing families, but in their ancestry belong somewhere between those two extremely dissimilar extinct families, the Hesperornithidæ and the Ichthyornithidæ. The revelations made by the precious remains of those two toothed types throw a bright light on one side of these questions of origin and relationship, but intensify the darkness of the other side.

Though both groups are adapted for an aquatic life, they are very sharply defined from each other. The ducks are more or less terrestrial, but are also swimmers; while the auks are not adapted for a land life, but are at home and at ease in the denser or rarer medium—they can dive and fly.

From the ontological standpoint, it will be conceded that that which has dominated the whole bird form is the wing, and embryology shows that this is merely the modified fore-paddle of a low gill-breathing amphibian—a nailless fore-paw. But the nails or claws do appear; yet, in the wing, they are out of place; and this reptilian stage is only transient. If the bird is, indeed, the child of the reptile, it must forget its father's house; it must proceed beyond its progenitor. But if we are willing to see the bird's wing grow, not out of a perfect and typical cheiropterygium, but out of an ichthyopterygium in an unsettled state, ready for transformation into the higher type of limb, then the difficulty is solved. It was a fish paddle; it was not to become a fore-foot; it did change into the framework of a bird's wing; in that respect it is a perfect thing; as a paw, it is an abortion. But an organism moves together in all its parts, if it moves at

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